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The more the merrier - Federated learning from local sphere recommendations

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Introduction and Motivation

- Thinking about Machine learning from a *European* startup perspective

- Which brings a few particular challenges with it:
  - Usually less startup capital than U.S. competitors
    => therefore less money for computing power
  - much fewer possible customers (initially) than Asian competitors
    => less initial data
  - GDPR is a major impediment
    => expressely prohibits use of personal data...

- Maybe we can circumnavigate all those hurdles via
  Client-side Machine Learning

Introduction and Motivation

- How far away are relevant decision points within a social networks usually?
- Leskovec, even back in 2006 observed recommender cascades within an online shopping system
  - for 3 out of 4 products: maximum size of cascade was < 10

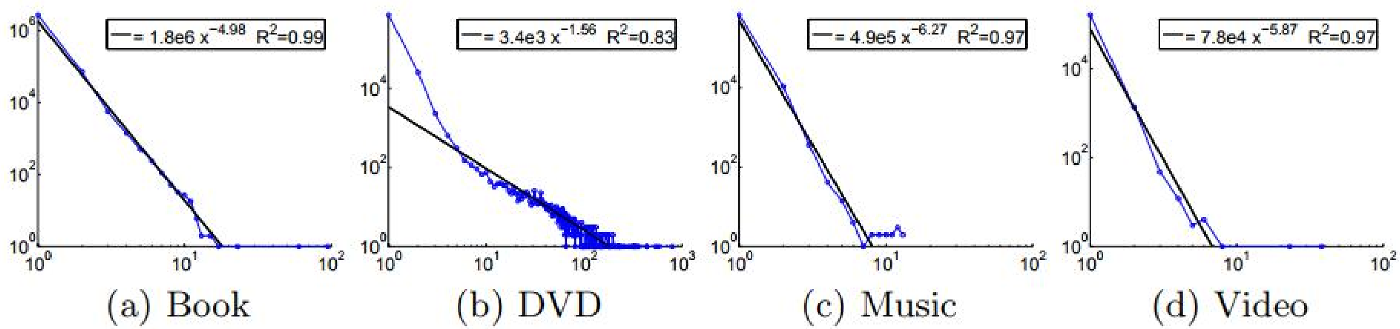

Fig. 1. Size distribution of the cascades for the four product types (log size of cascade vs. log count). Superimposed line presents a power-fit. R^2 is the coefficient of determination.

Leskovec, Jure, Ajit Singh, and Jon Kleinberg. "Patterns of influence in a recommendation network." Pacific-Asia Conference on Knowledge Discovery and Data Mining. Springer, Berlin, Heidelberg, 2006.

Recommendation Cascades

- most were not chains, but one node influencing many others (splits) or several recommendations directed at one node (merges)

- single recommendations made up the majority of 'cascades'

- overall, the average ego network from which relevant recommendations originated was little more than 1(!)

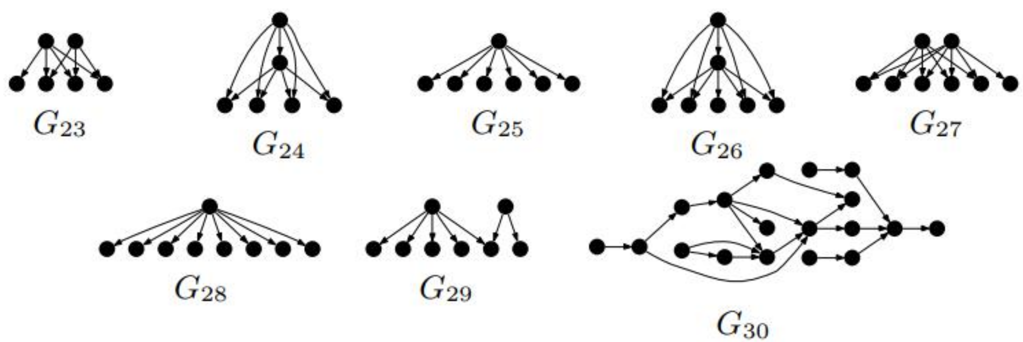

Fig. 2. Typical classes of cascades. G_{23}, G_{27}: nodes recommending to the same set of people, but not each other. G_{24}, G_{26}: one node recommends to another, and both recommend to the same community. G_{25}, G_{28}, G_{29}: a flat cascade. G_{30} is an example of a large cascade.

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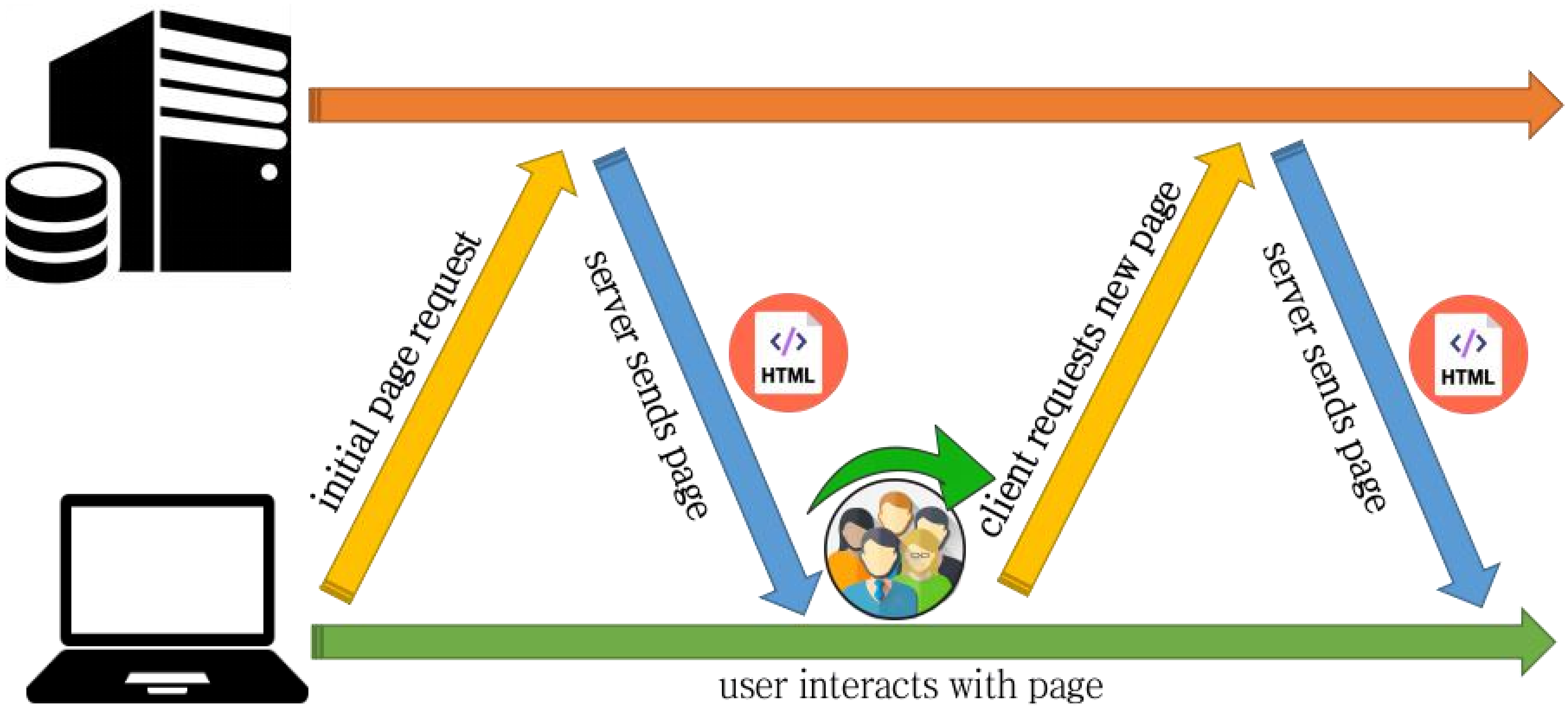
Introduction and Motivation

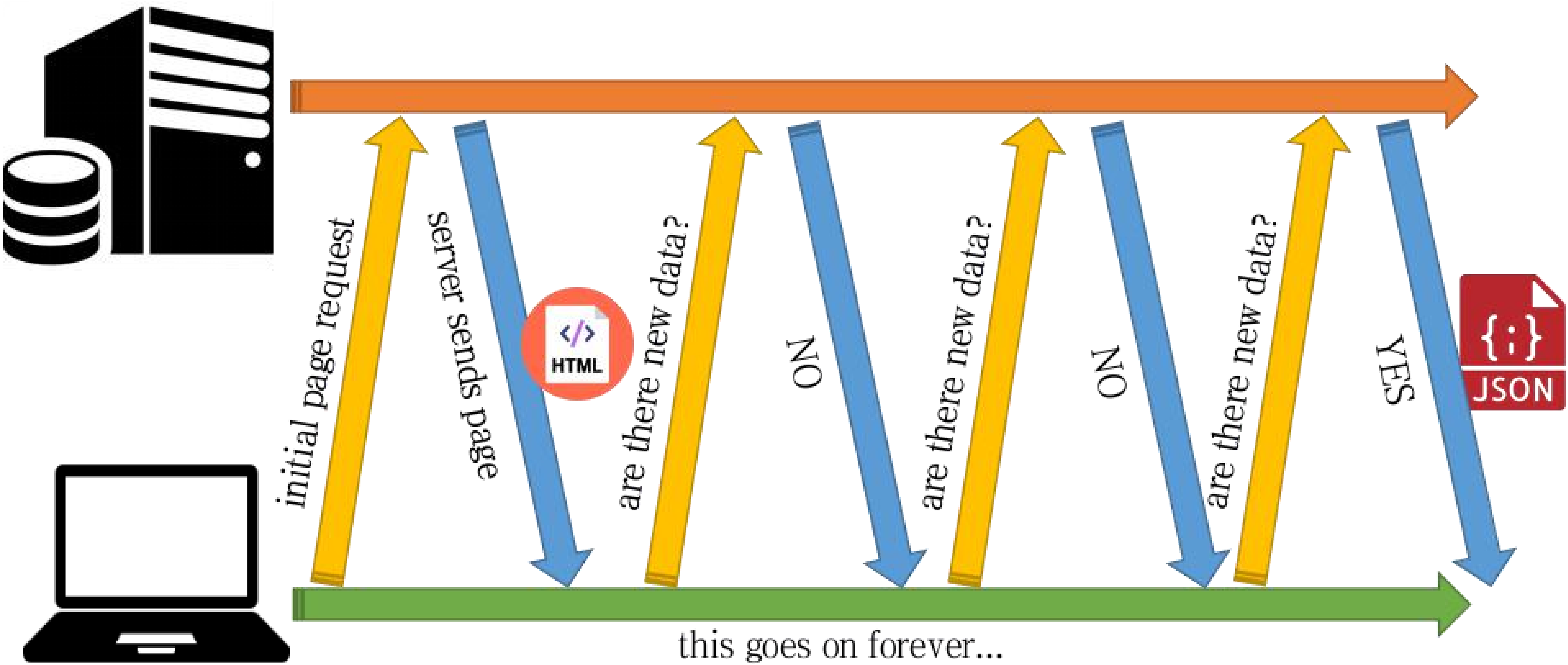
- the FB graph has been estimated to have a diameter of as low as 4
- because of many loose contacts instead of friends
- the diameter is shrinking with new connections
- although the graph is globally very sparse, individual node neighborhoods contain surprisingly dense structure
- Conclusion: We dont need the whole graph to calculate good recommendations - it might be possible to just take a node's immediate vicinity into account!

Traditional request / response cycle

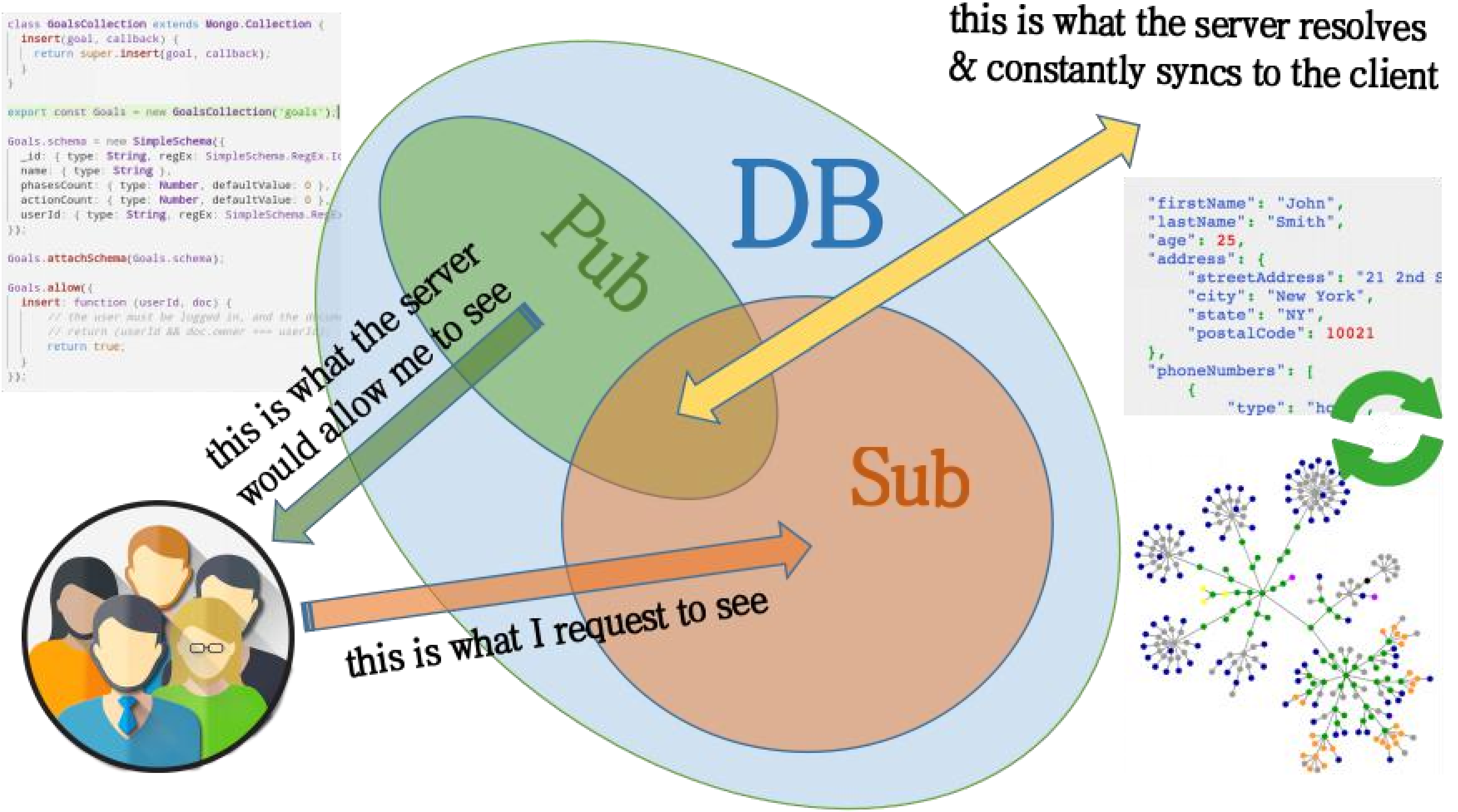
Traditional request / response model < 2005



Longpolling via Ajax 2005 - 2012 (& still in use)



Modern Pub/Sub with constant synchronization



Consequences of Pub/Sub

- This means in effect, that all information within the neighborhood of a node (if you see it graph theoretically) is constantly available within the browser / mobile device

    - my direct friends on a social network
    - all the information within my project group

- Combining those two views, we see that a majority of relevant recommendations could also be computed client-side...

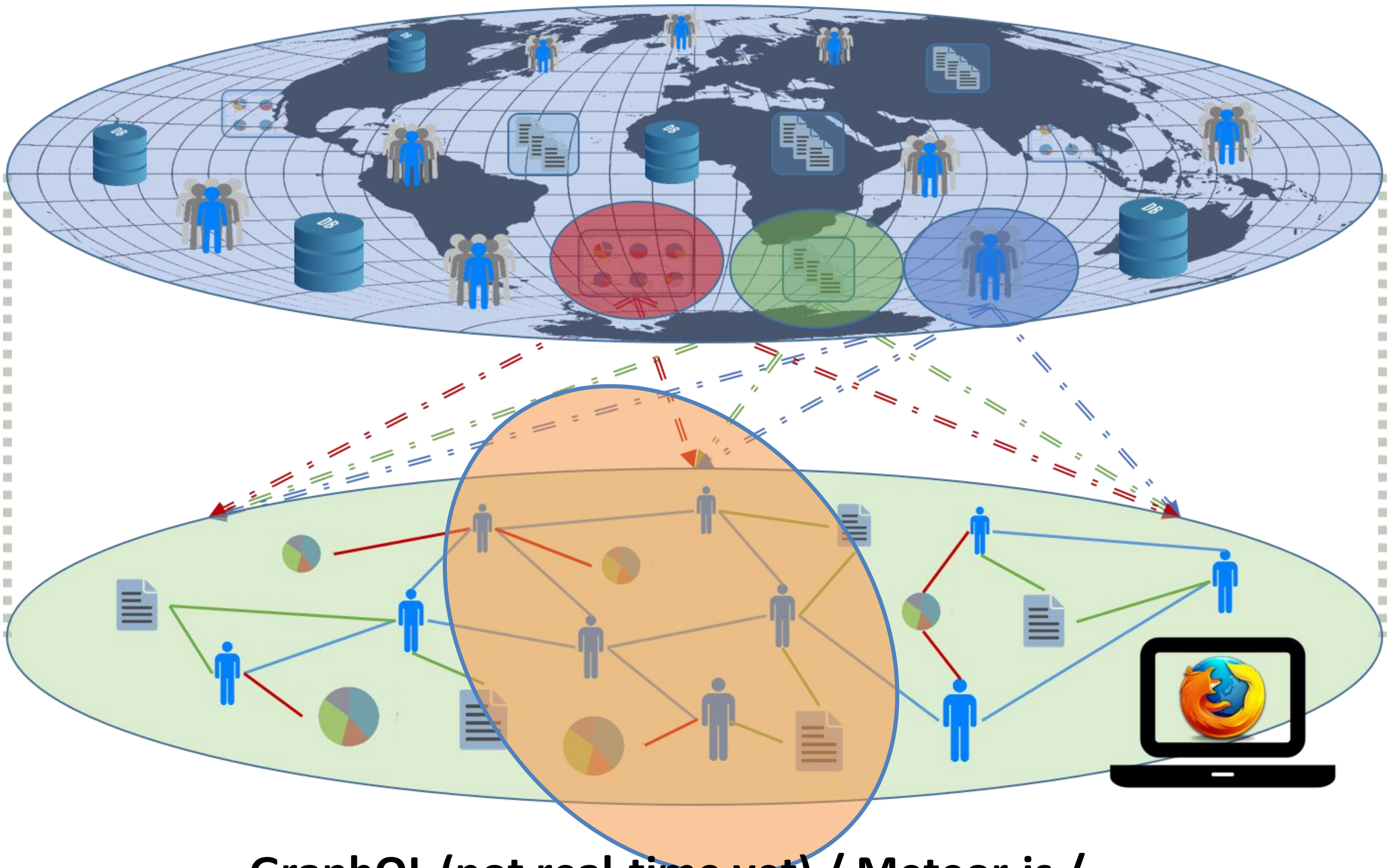
Global sphere / Local sphere

- Many globally distributed databases *dont have to / cannot be* implemented as a graph (AFAIK facebook also does not store one central graph)
  - would need too many globally propagating updates
  "the consequences of a tiny little update could affect the farthest reaches of the global graph"
  - huge problem for graph databases

- The local sphere can get it's information from many pub/sub mechanism targeting different endpoints in the global sphere

- The local sphere is a superset of the actual user's data, but user's data plus it's relevant vicinity

Global Sphere / Local Sphere / User data



GraphQL (not real-time yet) / Meteor.js / ....

Advantages

- GDPR says processing of personal data is expressely prohibited
  - but they are talking about data you **collected**
  - what if you haven't collected it because it never left the users' device?

- You can potentially use a wealth of information available on the client device you could never access server-side

  - address book
  - calendar
  - GPS
  - local files
  - ....

Advantages (coming back to the startup idea)

- BYOCP - "Bring your own computational power"
  - World's fastest supercomputer can do 93 Petaflops
  - A Geforce 1080 runs at about 12 Teraflops (single prec.)
  - You need ~7,750 customers with such cards to reach the TaihuLight
  - iPhone 7: GPU operates at 729.6 GFLOPS
  - ~130k iphones stack up to the TaihuLight

- of course those are very superficial & unrealistic numbers, but they give a good feeling about the order of magnitude we're talking about

- a few hundred thousand users is not much for a successful startup today => SCALABILITY !!!

Proposed mechanism

1. Pub/Sub keeps the local sphere in sync with global data

2. Local algorithms compute recommendations
   - these can also come from a client-side crawler (like the FB crawler which scans URLs you paste into a comment field and extracts images from a website etc.)

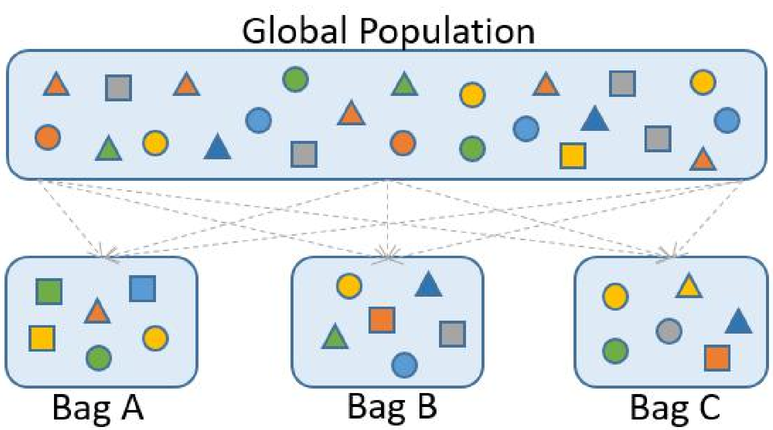
1. Upon user acceptance, a new node is introduced into the local sphere + updated to the global sphere

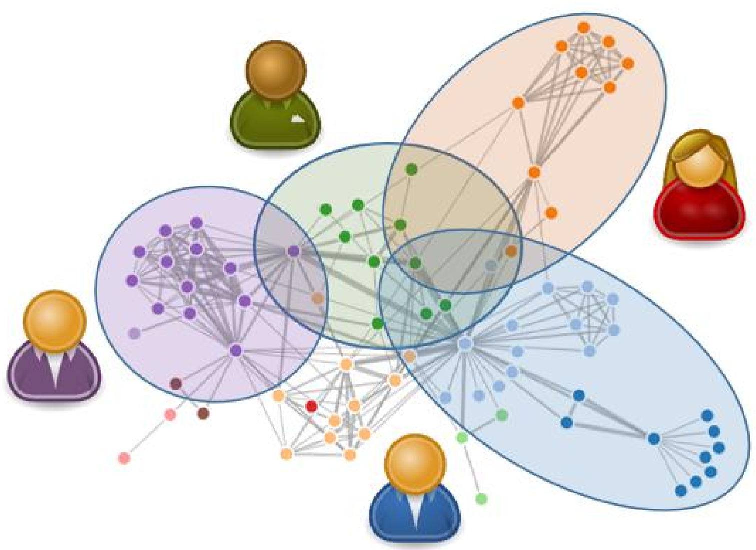
2. Client devices with overlapping local spheres now receive that node in the background

3. Their recommenders respond...

Machine Learning / Conclusion

- Maybe it's even possible to implement Machine Learning paradigms on such a distributed platform (see bagging below)
- In the end, we might not even have to curate a global graph anymore - it could be a 'ghost-like', implicit instantiation of the sum of all local spheres....





Thank you!